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PFBR Kalpakkam — India Enters Stage 2 of Its Three-Stage Nuclear Programme

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PFBR Kalpakkam — India Enters Stage 2 of Its Three-Stage Nuclear Programme

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2 tags

WHY IN NEWS

The Prototype Fast Breeder Reactor (PFBR) at Kalpakkam, Tamil Nadu achieved **first criticality on April 6, 2026 at 08:25 PM IST** — the moment when a self-sustaining nuclear chain reaction was achieved for the first time in the reactor. Prime Minister Narendra Modi highlighted this as a “historic milestone” in his Mann Ki Baat 133rd episode on April 26. The PFBR marks India’s **entry into Stage 2 of its three-stage nuclear programme**, designed by Homi J. Bhabha in the 1950s to eventually harness India’s vast thorium reserves.

WHAT IS FIRST CRITICALITY?

First criticality is the moment when the nuclear fission chain reaction in a reactor becomes self-sustaining — each fission event produces enough neutrons to trigger at least one more fission. It is not the same as power generation or grid connection. The sequence is:

- ① **First criticality** — self-sustaining chain reaction achieved (✓ Done: April 6, 2026)
- ② **Low-power physics experiments** — reactor behaviour verified at minimal power
- ③ **Power ascension** — gradual increase in power output with safety monitoring
- ④ **Grid connection and commercial operation** — electricity to the grid (pending AERB approval)

THE PFBR: TECHNICAL PROFILE

SPECIFICATION	DETAIL
Type	Pool-type, sodium-cooled Fast Breeder Reactor
Capacity	500 MWe (electric) / ~1,250 MWth (thermal)
Location	Kalpakkam (Kokkilamedu), near Chennai, Tamil Nadu
Operator	BHAVINI (Bharatiya Nabhikiya Vidyut Nigam Limited)
Designer	IGCAR (Indira Gandhi Centre for Atomic Research), DAE
Fuel	Uranium-Plutonium Mixed Oxide (MOX) — from PHWR spent fuel reprocessed at BARC
Coolant	Liquid sodium (not water) — enables fast neutron spectrum
Blanket material	U-238 (breeds Pu-239); Th-232 (breeds U-233 for Stage 3)
Breeding ratio	>1 — produces more fissile material than it consumes
Expected commissioning delay	Originally planned for 2010; achieved first criticality in 2026

INDIA'S THREE-STAGE NUCLEAR PROGRAMME

Designed by Dr. Homi J. Bhabha to overcome India's limited uranium reserves and utilise its vast thorium reserves:

STAGE	REACTOR TYPE	FUEL	STATUS
Stage 1	Pressurised Heavy Water Reactors (PHWR)	Natural uranium	Operational — 22 reactors including Rajasthan, Madras, Kakrapar, NAPS
Stage 2	Fast Breeder Reactors (FBR)	Pu-239 from Stage 1 spent fuel; breeds more Pu + U-233	PFBR achieved first criticality — April 6, 2026
Stage 3	Advanced Heavy Water Reactors (AHWR) / Thorium reactors	U-233 bred in Stage 2 + Th-232	R&D stage at BARC

The logic: Stage 1 creates spent fuel containing Pu-239. Stage 2 burns Pu-239 in FBRs while using a Th-232 blanket to breed U-233. Stage 3 uses U-233 to power AHWR reactors fuelled primarily by thorium. India has ~950,000 tonnes of thorium — enough for centuries of power generation at scale.

WHY IT TOOK 15+ YEARS LONGER THAN PLANNED

The PFBR was originally sanctioned in 2004 with a target commissioning date of 2010. Delays arose from:

- **Sodium handling complexity** — liquid sodium burns on contact with air/water; requires specialised engineering
- **Fuel fabrication** — MOX fuel requires reprocessed Pu from PHWR spent fuel; supply chain delays
- **Safety approvals** — Atomic Energy Regulatory Board (AERB) requirements; post-Fukushima (2011) safety reviews tightened standards globally
- **Supply chain** — highly specialised components (steam generators, sodium pumps) with limited domestic manufacturing base

INDIA'S CONTEXT: ONLY A HANDFUL OF NATIONS OPERATE FBRs

COUNTRY	REACTOR	STATUS
Russia	BN-800 (Beloyarsk), BN-1200 (under construction)	Operational since 2016
China	CFR-600	Commissioned 2023
India	PFBR (Kalpakkam)	First criticality April 2026
France	Superphénix	Shut down 1997
Japan	Monju	Shut down 2016

India's PFBR is the **third country** currently operating a fast breeder reactor, after Russia and China.

PFBR AND THE SHANTI ACT CONNECTION

The SHANTI Act (Sustainable Harnessing and Advancement of Nuclear Energy for Transforming India), passed in December 2025, enables private Indian companies to enter the nuclear power sector for the first time. The PFBR itself remains a government project under BHAVINI/DAE. However, PFBR's success:

- Validates indigenous FBR technology, providing a reference design for future units

- Makes Stage 3 (thorium) technically credible, supporting long-term energy planning
- Strengthens the case for the CEA's 100 GW nuclear target by 2047

India plans **six more FBRs at Kalpakkam** following PFBR's successful commissioning.

UPSC RELEVANCE

PAPER	ANGLE
GS3 — S&T	Three-stage nuclear programme; PFBR technical details; FBR vs PHWR
GS3 — Energy	India's nuclear energy targets; SHANTI Act; 100 GW by 2047
GS2 — Governance	DAE regulatory structure; AERB; nuclear liability

Mains Keywords: PFBR, BHAVINI, IGCAR, three-stage nuclear programme, fast breeder reactor, MOX fuel, breeding ratio, first criticality, thorium, SHANTI Act

Facts Corner

ITEM	FACT
PFBR first criticality	April 6, 2026 at 08:25 PM IST
PFBR capacity	500 MWe (largest FBR outside Russia's BN-1200)
Designer	IGCAR (Indira Gandhi Centre for Atomic Research)
Operator	BHAVINI, under DAE
Fuel	Uranium-Plutonium MOX (Pu-239 from PHWR spent fuel)
Coolant	Liquid sodium (not water)
Delay	Originally planned for 2010; 15+ years behind schedule
Stage 2 significance	Unlocks Pu-239 for Stage 3 thorium reactors
India's thorium reserves	~950,000 tonnes; world's second-largest (25% of global)
Other operating FBRs	Russia BN-800 (2016); China CFR-600 (2023)

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